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March 8, 1994

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"Draft"

Barneys Canyon Mine - Waste Dump Management Plan

This letter contains a summary of the presentation made by Barneys Canyon Mine representatives to DWQ and DOGM personnel on Feb. 3, 1994.

1. **Acid Rock Drainage**

The major concern regarding mine waste rock is its potential to generate acidic water discharge due to oxidation and mobilization of sulfide compounds contained in the rock. Barneys Canyon Mine has carried out extensive chemical analysis of the waste rock materials at four different pit sites (Barneys Canyon Pit, Melco Pit, SBCS and NBCS Pits). While sulfides are present in low concentrations at all sites the analysis showed that there is in all cases, more than sufficient neutralizing potential within the host rock to ensure there is no acid discharge from a mixed rock pile. The supporting data and conclusions were presented in previously submitted reports from our consultants (SRK) dated January 15, March 18 and April 15, 1993.

The meeting agreed that acid drainage would not be a concern as long as the waste dumps are well managed.

2. **Sulfate Mobilization**

Although acid drainage is not likely to be a problem there will always be potential for oxidation of sulfides leading to formation of soluble sulfates which could, in the long term (+100 years) reach the water table and raise background levels of sulfate or TDS. The effect of this addition to groundwater is extremely difficult to predict due to the long time scale and considerable natural variation in groundwater quality. For example the background values of sulfate in the existing monitoring wells on site vary from 30 to 130 ppm and TDS backgrounds vary from 550 to 950 ppm. The reasons for this natural variation are not known and hence it is difficult to know whether a change in background is due to contamination or to natural variations in water quality.

Any attempt to superimpose estimates of water infiltration rate, dispersion or quality of water emanating from waste dumps - a process that could take from 100 to 350 years depending on the dump size - becomes an exercise in futility.

For these reasons Barneys Canyon Mine does not intend to attempt to model the groundwater regime nor to monitor dump performance through the use of groundwater monitor wells.

3. Dump Planning

Barneys Canyon has already evaluated the chemical processes which may take place within dumped material. Initial tests have also been carried out aimed at evaluating the potential for infiltration of precipitation into waste dumps. In general the conclusions are that

a) Acid generation is not a concern for well mixed material.

b) Acid generation can occur within sulfide wastes if not mixed with neutralizing waste.

c) Water infiltration into dump surfaces is likely to be low. A typical dump surface has permeability of about 10^{-5} cm/s even if no special measures are taken to reduce infiltration.

d) Early estimates using the HELP computer model, are that infiltration through a dump can be limited to about 0.025 gpm per acre of surface area by using a simple vegetated cover on the dump surface. At these rates of infiltration the effect on groundwater which has a natural recharge rate of about 0.3 gpm per acre (over a much larger catchment area) is likely to be negligible.

All dump plans previously submitted to DOGM have been based on the principle that sulfide bearing waste which normally contains between 0.3% and 4% sulfur could be mixed with non sulfide waste to prevent acid generation. This is technically correct and will minimize the potential for acid formation. However it does mean that sulfide material is spread throughout large dumps covering up to 250 acres in area. In the event that, in future, unsatisfactory discharge did occur from dumps then the remediation problem would be immense. With this in mind Barneys Canyon has been considering segregation of sulfide bearing waste into much smaller engineered piles which would have greater potential for acid generation but at least would be clearly identified waste piles of manageable size and location if remediation should ever be needed.

Each of the planned mine dumps has been separately evaluated and this has led to a change in the dump plans from those previously agreed with DOGM.

4. Studies in Progress

The key to controlling groundwater quality is to control the infiltration rate of precipitation through the waste dumps. With this objective in mind Barneys Canyon has initiated engineering tests to determine the physical properties and permeabilities of typical waste material. The initial results are summarized in a report from our consultant HBT-Agra which is attached for your reference.

Using the engineering data, preliminary modelling of the dumps has been carried out using the HELP model in order to estimate the infiltration rate that can be expected from various types of dump cover.

It is estimated that infiltration can be kept to 0.5" per year (or less) and John Forth, Kennecott's geohydrologist has made estimates of the impact on groundwater as shown in the attached calculations. Conceptual model 1 assumes that duump infiltration will be diluted by groundwater recharge from the whole catchment basin in which a dump resides (increase in background sulfates of 1.9%). Conceptual model 2 assumes dilution by recharge from only a flowpath directly under the dump and shows an increase of 11.7% over background sulfate. In both cases the sulfate values remain far below normal sulfate levels allowed for drinking water.

The above studies are not yet definitive so it is our intent to continue tests and modelling with the assistance of consultants using the HELP and UNSAT2 models to better define the most suitable dump cover. The consultants will also assist us to develop field monitoring systems to check whether the models are correctly predicting field conditions. At present our intent is to design lysimeters to be placed 10 to 15 feet below the dump surface in order to determine the true infiltration rate through the designed dump cover.

5. Current Dump Plans

Our current thinking on waste dumps is as follows:

5.1 Barneys Canyon 6300 and 6500 Dumps

These dumps are nearly completed and cover approximately 150 acres and contain about 20 million tons of mixed rock waste. The waste host consists largely of dolomite and calcareous sandstones which have overwhelming neutralizing capacity to prevent acid generation from contained sulfides. The dumps will be recontoured, topsoiled and vegetated.

5.2 SBCS Dump

This dump contains quartzites and sandstones which have sulfates (oxidized sulfides) intimately disseminated throughout the rock host. Acid potential is low and neutralizing capacity is more than adequate. As it is not possible to segregate the sulfate material it is intended that the dump will be covered and revegetated to minimize infiltration. This dump will cover 10 acres and contain 2 million tons of material. (John Forth's calculation of groundwater effect used this dump as the example.)

5.3 Melco 7200 South Dump Area

This partially completed dump consists of sandstone and quartzite with minor amounts of contained sulfides. While the potential exists to continue mixing sulfide with the oxide waste as per the original dump plan, we now intend to segregate the sulfide waste into a discreetly engineered pile which will be suitably covered to prevent infiltration.

The total dump will cover approximately 100 acres and contain about 45 million tons. Of this some 3 million tons will contain sulfides to be stored in a discrete pile.

5.4 Melco North Dump

This dump will commence construction in mid 1994 and will ultimately cover 250 acres containing about 50 million tons. Due to the mining sequence it will not be possible to properly mix sulfide waste with neutralizing waste in this dump. Thus the plan will be to segregate the sulfide waste and to use it to backfill the NBCS pit. The NBCS pit will be situated some 500′ above the water table in a stable sandstone host which is moderately neutralizing. The sulfide waste will amount to some 2 million tons and will cover about 10 acres of the pit. A suitable cover will be designed to minimize infiltration.

5.5 Sulfide Dump Cover

For the sulfide waste piles our current thinking is to provide a cover similar to the permitted Bluewater Lagoon on Kennecott property. On top of the compacted sulfide will be a 12" clay layer or similar low permeability material, itself covered by a coarse protective material, topsoil and vegetation. The final details of the design will be confirmed once our consultants have completed their studies.

6. Questions raised in DWQ letter dated April 1, 1993

6.1 At present sulfide waste can be separated from oxide waste by visual inspection (colour contrast) alone. In practice this means that the dividing line is about 0.1% sulfur as the oxide waste has sulfur values far below 0.1%. In future the colour contrast may not be as clear and so it is our intent to purchase a sulfur analyzer in order to carry out laboratory analysis to define sulfide/non sulfide waste. Early results indicate that samples with a Sulfur content of less than 0.5% have net neutralizing potential (see attached graph). Further analyses will be carried out in the range 0.1% to 0.5% Sulfur in order to determine an appropriate cut off value.

6.2. The number and size of waste dumps needed has been described in Section 5 above.

6.3 Where sulfide is exposed in pit highwalls we are still evaluating alternative control methods. Bearing in mind that the exposed sulfide will rapidly oxidize and that acid runoff will only occur during short rainfall or snow melt events, the problem is not considered major.

Possible alternatives considered are:

a) Apply a phosphate or silicate spray onto the sulfide to coat it and retard oxidation. The spray coat may last for 10-50 years but would not be permanent. This could be useful to delay acid formation in the Barneys pit which will later naturally fill with water which will effectively prevent long term oxidation.

b) Collect pit runoff and direct it away from the exposed sulfides.

c) Place neutralizing lime/limestone/phosphate on pit benches to neutralize runoff.

d) Place neutralizing waste in the pit bottom to neutralize runoff.

e) Create an infiltration zone to ensure runoff does not stand in contact with sulfides in the pit bottom.

Further field testing is required to determine the best course of action for each pit. The final plan will probably include several of the above options.

6.4 Sulfide waste will (probably) be clay covered as described in section 5.5 above.

6.5 Sulfide in existing waste dumps is relatively minor in quantity and is well mixed with oxide waste. All such dumps will be covered and revegetated to minimize infiltration in accordance with designs to be confirmed by our consultants.

7. <u>Current Status</u>

Barneys Canyon has retained consultants, Water Waste and Land Inc., to carry out design of dump covers using the HELP and UNSAT2 models to optimize the results. Dr. Dave McWhorter who is considered the foremost expert on infiltration studies has been retained as overview consultant for this work. Dr. John Lumley of HBT-Agra has been retained to help design lysimeters to carry out field monitoring of the results. Our consultants expect to complete their report the by end of April 1994. We should therefore be able to present our final dump plans in May.

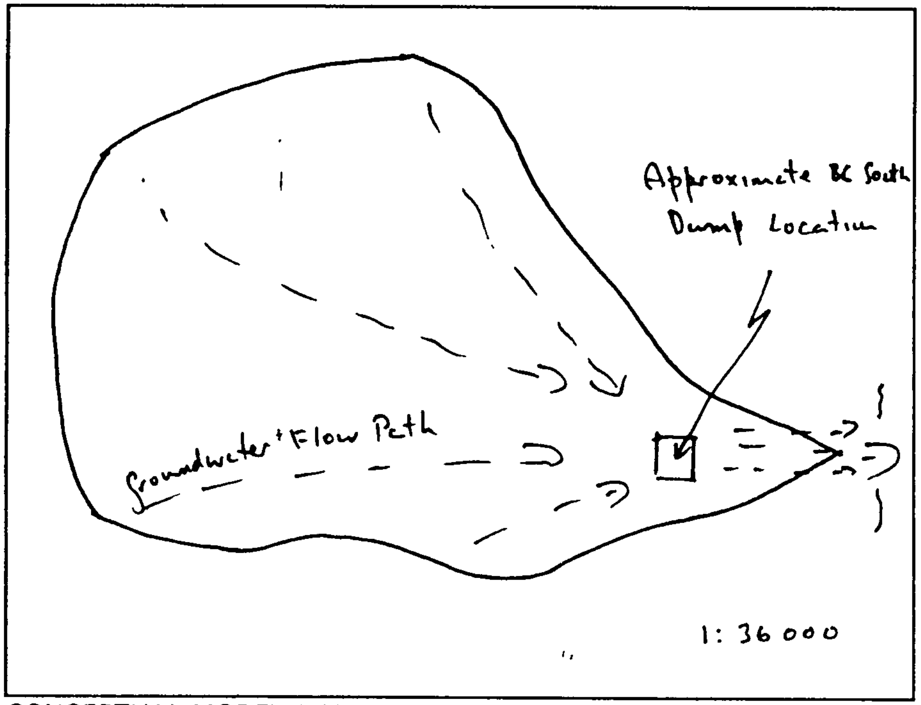
I trust this summary covers the areas of interest to you and answers all the questions raised in your letter of April 1, 1993 and your draft letter of March 7, 1994.

Yours sincerely,

D. I. Hodson

cc: C. S. Emmons
Z. Zavodni
J. Forth
M. L. Pagel

BC South Dump Catchment



CONCEPTUAL MODEL 1 (Assumes all catchment recharge available for dilution)

CONCEPTUAL GROUNDWATER FLOW MODEL

Assumption: Groundwater flow system is a subdued reflection of the surface topography

Catchment area = 1447 acres
Dump Area = 10 acres
Natural Recharge = 0.0014 to 0.0024 ft/day
(Water Resources of Salt lake County, Technical Publication No. 31, Dept. of natural resources, 1971)
Natural background SO_4 concentration = 60 mg/l

HYDROLOGICAL IMPACT CALCULATION

Catchment Recharge @ 0.0014ft/d = 449 gpm (1698l/min)

ASSUME DUMP RECHARGE CONTROLLED TO 0.5"/Y BY CONSTRUCTION OF A DESIGN COVER

Dump recharge = @0.5"/y = 0.26 gpm (1l/min)

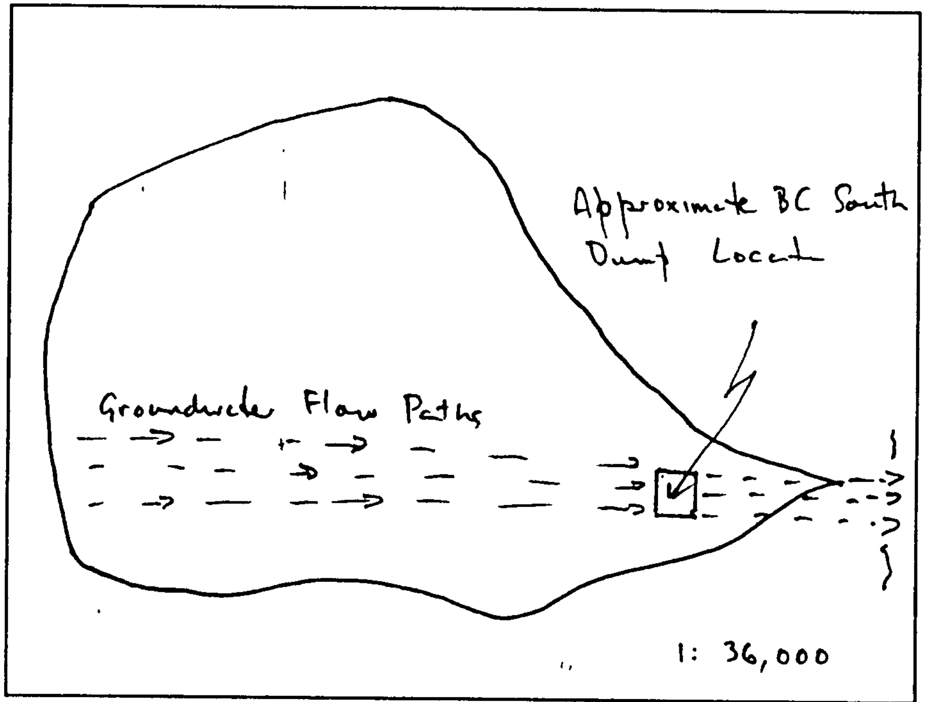
Natural Catchment SO_4 discharge = 53,442 kg/year
Dump generated SO_4 discharge @ 2000mg/l = 1050 kg/y

∴ ANNUAL INCREASE IN SO_4 DISCHARGE = 1.96%

∴ NEW SO_4 DISCHARGE CONCENTRATION = 61.1mg/l
(Note: original SO_4 concentration = 60 mg/l)

NOTE: This model uses low estimate of average recharge but assumes complete mixing with all catchment recharge. The result indicates that there is, even assuming low recharge estimate, sufficient water to achieve sulfate dilution so that background concentrations will only be increased by 1%.

BC South Dump Catchment



CONCEPTUAL MODEL 2 (Assumes only flow path recharge is available for dilution, with no dispersion)

CONCEPTUAL GROUNDWATER FLOW MODEL

Assumption: Groundwater flow follows non-divergent/non-convergent paths.

Flow Path Catchment area = 235 acres
Dump Area = 10 acres
Natural Recharge = 0.0014 to 0.0024 ft/day
(Water Resources of Salt lake County, Technical Publication No. 31, Dept. of natural resources, 1971)
Natural background SO_4 concentration = 60 mg/l

HYDROLOGICAL IMPACT CALCULATION

Flow Path Recharge @ 0.0014ft/d = 73 gpm (276l/min)

ASSUME DUMP RECHARGE CONTROLLED TO 0.5"/Y BY CONSTRUCTION OF A DESIGN COVER

Dump recharge = @0.5"/y = 0.26 gpm (l/min)

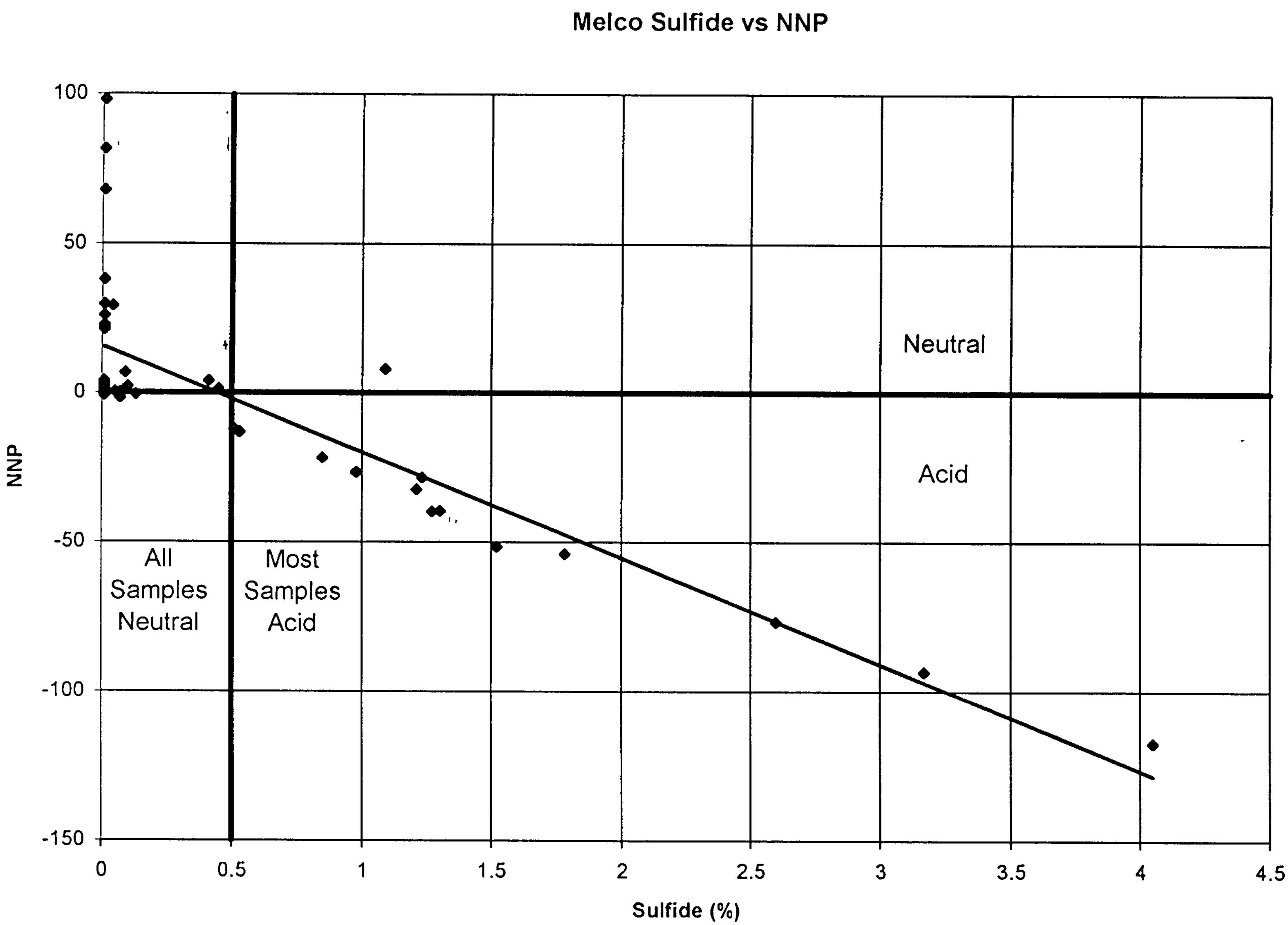
Flow Path Catchment Natural SO_4 discharge = 8704 kg/year
Dump generated SO_4 discharge @ 2000mg/l = 1050 kg/y

∴ ANNUAL INCREASE IN SO_4 DISCHARGE = 11.7% (In flow path zone only)

∴ NEW SO_4 DISCHARGE CONCENTRATION = 67mg/l (In flow path zone only)

(Note: original SO_4 concentration = 60 mg/l)

NOTE: This model assumes no dispersion, and no attenuation with groundwater from outside the flow paths which pass under the dump. This is, accordingly, a worst case answer with respect to mass loading to the groundwater system. The down gradient distance for the mixing to occur has not yet been determined. Because of the density difference between the flux from the dump, and the natural groundwater, and because of dispersion, the mixing process is expected to be accentuated.



Melco Sulfide vs NNP
NNP
Sulfide (%)
100
50
0
-50
-100
-150
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Neutral
Acid
All Samples Neutral
Most Samples Acid